CONCRETE information

Strikingly handsome office building achieved through the use of architectural concrete. Location—Los Angeles, California. Building owned by Massachusetts Mutual Life Insurance Company. Principal tenant is Remington Rand, Inc.

Associated Architects: Kahn and Jacobs and Welton Beckett, F.A.I.A.
Associated Engineers: Weiskopf and Pickworth, New York
Murray Erick Associates, Los Angeles
General Contractor: William Simpson Company

PORTLAND CEMENT ASSOCIATION
33 West Grand Avenue, Chicago 10, Illinois

Member of The Producers' Council

HOW PCA SERVES THE ARCHITECT

The Portland Cement Association is headquarters for technical service to architects on problems relating to portland cement and concrete. It also is a clearinghouse for reliable, up-to-the-minute information on cement and concrete and on design and construction procedures.

In its laboratories near Chicago and in far-flung field research projects from coast to coast scientists and technicians constantly seek better concrete and better design and construction procedures. When improvements are evolved the data are made available immediately through PCA's technical service and educational programs.

Technical assistance of trained PCA field engineers on concrete design or construction problems is available locally in 46 states, the District of Columbia and British Columbia. The PCA's district offices are listed on the back page of this catalog. Call the one in your area.

Architects are invited to attend short courses conducted by the Association staff. These courses demonstrate to the architect and engineer new methods and practices as well as time-tested ways of making quality concrete and designing low-annual-cost concrete structures. Similar subjects are covered graphically in a wide range of Association sound motion picture films, most of them in color. For information on either short courses or films get in touch with the Association office in your area.

The Association's free booklets and information sheets place at the architect's finger tips a handy reference to concrete design and construction problems. Some of these booklets relating to concrete masonry and concrete floors are listed on the back page of this catalog. Some of those on structural subjects are listed at the right.

DESIGN AND CONTROL OF CONCRETE MIXTURES—Explains water-cement ratio, field controls methods of designing mixtures of required strength and durability and making field tests. Includes ASTM Standard Specifications for Concrete and Concrete Aggregates. 68 pages.

CONTINUITY IN CONCRETE BUILDING FRAMES—Contains analysis of reinforced concrete building frames subject to vertical or horizontal load—wind pressure and earthquakes. Offers fast, easy, convenient procedures for office design practice. 56 pages.

HANDBOOK OF FRAME CONSTANTS—62 tables of carry-over and stiffness factors and fixed end moments containing 27,050 constants for 1,390 members. Expedites the analysis of almost any indeterminate structure. Covers a wide range of symmetrical and unsymmetrical members with parabolic and straight haunches. 32 pages.

REINFORCED CONCRETE DESIGN HANDBOOK—Contains (1) detail examples showing how to solve all ordinary problems in designing reinforced concrete, (2) derivations of equations applied in the examples, (3) tables of design data. 132 pages.

TILT-UP CONSTRUCTION—History, design, construction details and uses of this modern, fast, economical type of construction. Profusely illustrated. 32 pages.

CONCRETE FOR HOSPITALS—Contains suggestions for the design and construction of 100-bed hospitals as well as small rural hospitals. It covers framing, floors, walls and details. 32 pages.

COLOR IN ARCHITECTURAL CONCRETE—Describes production of colored concrete, including multicolored patterns, by the aggregate transfer method. 16 pages.

ARCHITECTURAL CONCRETE SPECIFICATIONS

MATERIALS

(1) Portland Cement—Portland cement shall comply with the "Standard Specifications for Portland Cement", (ASTM Designation: C150-55), or the "Standard Specifications for Air-Entraining Portland Cement", (ASTM Designation: C175-55) and shall be Type——.

Note—These specifications cover the types of portland cement listed below and provide that when no type is specified, the requirements of Type I and Type IA are to govern.

The letter "A" after type designates air-entraining portland cement. Cements conforming to the requirements for Type IV and Type V are not usually carried in stock. In advance of specifying their use, purchasers or their representatives should determine whether these types of cement are, or can be made available.

Type I or IA—for use in general concrete construction when the special properties of the other types are not required.

Type II or IIA—for use in general concrete construction exposed to moderate sulfate action or where moderate heat of hydration is required. Example: concrete exposed to sulfates where the concentration is not unusually severe, or heavy sections of concrete placed in warm weather.

Type III or IIIA—for use when high-early-strength is required.

Type IV—for use when a low heat of hydration is required. Example: large masses of concrete such as gravity dams.

Type V—for use when high sulfate resistance is required. Example: concrete exposed to soils or waters of high alkali content encountered in a few locations, principally in some western states.

(2) Fine Aggregate—Fine aggregate shall consist of sand having clean, hard, durable, uncoated grains, free from deleterious substances, and shall range in size from fine to coarse within the following percentages by weight:

Passing No. 4 sieve	95 to 100 per cent
Passing No. 16 sieve	45 to 70 per cent
Passing No. 50 sieve	15 to 30 per cent
Passing No. 100 sieve	3 to 8 per cent

Volume removed by sedimentation—not more than 3 per cent.

Not more than 35 per cent shall pass a standard size sieve and be retained on the next smaller standard sieve.

(3) Coarse Aggregate—Coarse aggregate shall consist of crushed stone, gravel, slag or other approved inert materials with similar characteristics or combination thereof, having clean, hard, durable, uncoated particles free from deleterious matter. After acceptance of a grading, a variation in the amount passing any sieve size of more than 10 per cent of the total will not be permitted and the grading shall be within the following percentage, by weight:

Passing a 1½-in. sieve	95 to 100 per cent
Passing a ¾-in. sieve	35 to 70 per cent
Passing a ⅜-in. sieve	10 to 30 per cent
Passing a No. 4 sieve	0 to 5 per cent

The Architect may at any time require delivery and stock piling of the coarse aggregate in two sizes divided on the ¾-in. sieve. When the aggregate is required to be so divided the two sizes shall be used in such proportions that the combined aggregates will meet the grading given above.

(4) Deleterious Substances—Deleterious substances shall not be present in the aggregates in excess of the following amounts:

Aggregate	Deleterious substance—percentage by weight			
	Clay lumps	Coal and lignite	Material finer than No. 200 sieve	Soft fragments
Fine	1	½	4	...
Coarse	¼	½	1	3

(5) Soundness—The fine and coarse aggregates when subjected to five alternations of the sodium sulfate soundness test (ASTM Designation: C88-55T) shall not show an average weighted loss of more than 10 per cent for the fine aggregate and 13 per cent for the coarse aggregate, unless evidence satisfactory to the Architect is furnished that concrete of comparable proportions in which similar materials from the same sources were used, has been exposed to natural weathering for a period of at least 5 years without appreciable disintegration.

(6) Mixing Water—Water shall be clean and free from oil, acid and injurious amounts of vegetable matter, alkalies, or other salts.

(7) Metal Reinforcement—Metal reinforcement shall conform to the requirements of the "Tentative Specifications for Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement" (A305-53T) and to the requirements of the "Tentative Specifications for Billet-Steel Concrete Reinforcement Bars" of intermediate grade (ASTM Designation: A15-54T) or the "Tentative Specifications for Rail-Steel Concrete Reinforcement Bars" (ASTM Designation: A16-54T).

Wire for concrete reinforcement shall conform to the requirements of the "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement" (ASTM Designation: A82-34).

STORAGE OF CEMENT AND AGGREGATES

(8) Storing Cement—Cement shall be stored in a weathertight structure with the floor raised not less than 1 ft. from the ground in such manner as to permit easy access for proper inspection and identification of each shipment. Cement that has hardened or partially set shall be removed from the site and not used.

(9) Storing Aggregate—Fine and coarse aggregates shall be stored separately and in such manner as to prevent segregation of sizes and to avoid the inclusion of dirt and other foreign materials in the concrete. Fine aggregate shall be stockpiled at least 24 hours.

FORMS

(10) General—Forms shall conform to shape, lines and dimensions of the members as shown on the plans. They shall be properly braced or tied together to maintain position and shape and insure safety to workmen and passersby. Forms shall be made sufficiently tight to prevent leakage of mortar. All exterior forms shall be detailed and drawings submitted to the Architect for approval before forms are fabricated or erected.

Studs and wales shall be not less than 2x4 in. S1S1E or S4S except that 3x4-in. studs S1S1E or S4S shall be used at the vertical joints in plywood sheathing. All studs and wales shall be No. 2 or better Southern pine, Douglas fir or equal. All wales shall be doubled and the joints in the top and bottom pieces of each wale shall be staggered at least the spacing of the form ties. Vertical kick strips shall be used at the intersection of the wales at all external corners and the corners shall be tightly wedged to prevent leakage.

Forms shall be substantial and designed to resist the pressure to which they are subjected, but under no conditions shall studs be spaced more than 16-in. centers when used with 1-in. sheathing or $\frac{11}{16}$-in. or thicker structural grade plywood, but studs shall not be spaced more than 12-in. centers for ⅝-in. plywood, and when used with plywood having the grain of the outer plies parallel to the studs the stud spacing shall be reduced 2 in. for all thicknesses of plywood. Wales shall not be spaced more than 24-in. centers and ties shall be spaced not more than 27-in. centers when used with double 2x4-in. wales. Ties shall have a minimum working strength of 3,000 lb. when fully assembled.

If a lift of forms is 10 ft. or more high, and at all spandrel beams regardless of the height of the forms, double 2x6-in. vertical wales spaced not more than 10-ft. centers and extending the full height of the forms shall be bolted to every other set of horizontal wales to maintain forms in straight, true alignment.

Window and door bucks shall be made of 2-in. stock and the wall sheathing shall be securely nailed to the bucks with 8d double-headed nails.

Temporary openings shall be provided in the inside form of all wall forms and in column forms to facilitate cleaning and inspection immediately before depositing concrete. When wood sheathing is used for the inside form, the bottom board shall be fitted and removed to provide a continuous cleanout space and if plywood is used the forms shall be started with a 6-in. wide piece for the same purpose. Forms shall be so assembled that their removal will not damage the concrete.

(11) Exterior Forms—Unlined—Unlined forms shall be used for the outside face of all exterior walls and all other exposed surfaces where indicated on the drawings. All forms shall be built in place except that panel forms may be used where a single panel will form an entire area from one reveal to another. The use of panel forms will not be permitted where the joints between adjacent panels must be made on flat surfaces or in any other conspicuous locations.

The contact surface of all unlined forms shall be constructed of No. 1 common dressed and matched Longleaf Southern yellow pine or Douglas fir boards.† This material shall be delivered to the site immediately on signing the contract and shall be sorted and graded on the job. The best 25 to 30 per cent of each load shall be selected for the outside face forms. The selected sheathing shall be stacked clear of the ground in layers separated by ¼-in. laths to facilitate air drying.

Note: Use the following paragraph in place of the preceding one and omit the fourth paragraph of this section if plywood is used for sheathing.

The contact surface of all unlined forms shall be constructed of ⅝ or ¾-in. 5-ply Douglas fir structural plywood of concrete form grade according to Bureau of Standards Commercial Standards CS45-48. All concrete form plywood shall be so designated by grade marking each panel. Full-sized sheets of plywood must be used except where smaller pieces will cover an entire area. The edges of all plywood sheets shall be straightened on the bench to insure close fitting, tight joints. All vertical joints shall be backed solidly and the edges of abutting sheets shall be nailed to the same stud with 6d box nails not farther apart than 8 in. Wherever panel forms are permitted by the Architect the joints shall be so constructed as to comply with the above requirements.

Vertical boarding shall have all vertical joints truly plumb and all horizontal boarding shall have all horizontal joints exactly level and without changes in level in any horizontal line. The vertical joints in horizontal boarding shall not be over one board wide and shall be staggered at least 2 ft. and shall not be made except at studs or girts. Each board shall be driven up snug and nailed to every stud or girt with 6d box nails. All 6-in. sheathing shall be double nailed, and 8 and 10-in. boards shall be nailed at both edges and at center. The three top boards adjacent to horizontal construction joints shall not be erected until after the wetting operation specified in Sec. 15 has been completed, and to fill the remaining space each board shall be ripped to approximately one-third of the height between the top full-width board and construction joint. Form boards may be re-used in contact with exposed surfaces if in satisfactory condition and the re-use is approved by the Architect.

When the outside form is erected and reinforcement is in place and before the inside form is erected the Architect shall be notified and the inside form shall not be placed until work already done is approved. Open joints which would permit leakage of grout shall be sufficient cause for rejection of forms. If, in the opinion of the Architect, pointing of an occasional, slightly open joint will prevent leakage, then such pointing shall be done with a mixture of equal parts of beef tallow and portland cement. Pointing shall be carefully done and there shall be no trace of the pointing mixture on the surface of the sheathing.

(12) Exterior Forms—Lined—Lined forms shall be used for outside face of all exposed exterior walls and all other exposed surfaces where indicated on the drawings. The backing for form lining shall be constructed of a good grade of form lumber that is solid, straight, and free from defects that might impair its

† If an impression in the concrete of knots and other flaws in the wood is desired No. 2 boards may be used. For rough-textured surfaces re-sawed square-edged No. 1 or No. 2 boards, or boards surfaced one side and two edges may be used with the rough side of the lumber used as the contact surface. The width of form boards varies from 4 to 8 in., depending on the scale of the building and the effect desired. Boards of 1-in. nominal thickness are generally used. ⅝-in. 5-ply Douglas fir plywood may be used in place of boards for sheathing where a surface practically free from joint lines is desired. Proper substitution should be made in the specifications to require the type of sheathing material to be used that will give the surface finish desired.

strength but need not be of the quality used for contact forms. Square-edged, sized lumber may be used for form boarding in place of shiplap or T&G.

The boarding for lined forms may be horizontal or vertical, depending upon convenience. Form sheathing shall be securely nailed to the studs and the edges of the boards shall be in contact to prevent any bulging of the lining.

Non-warping fibreboard not less than 3/16 in. in thickness, or 1/4-in. Douglas fir plywood, shall be securely nailed to the form sheathing. All lining material shall be used in as wide pieces as possible. Areas less than 4 ft. in width shall be lined with a single width of fibreboard or plywood.

Joints in lining and backing shall not occur at the same place and abutting edges of adjacent sheets shall be nailed to the same board. The lining material shall be nailed to the backing beginning at the center of the board and working toward the edges to prevent buckling. Three-penny blue shingle nails or similar nails with thin flat heads shall be used to attach lining material to sheathing. The nails shall not be farther apart than 8 in. along the edges and there shall be at least one nail for every square foot of surface. A joint approximately 1/16 in. wide shall be provided between the edges of adjacent sheets and such joints shall be filled with a mixture of equal parts of beef tallow and portland cement. Lining material may be re-used if it is in satisfactory condition and is approved by the Architect.

Fibreboard shall be thoroughly wet with water at least 12 hours before being used. The water shall be applied to the screen side of the board and the board shall be stacked screen side to screen side.

(13) Ornamental Detail—Ornamental concrete work shall be placed integrally with the body of the concrete in wood molds or plaster waste molds. Moldings, column fluting and simple ornament shall be formed with wood, using No. 2 or better Idaho white pine or equal. No material thicker than 2 in. shall be used without approval of the Architect and members making up wood molds shall be kerfed on the back wherever such members may become wedged between projections in the ornament. Molds shall be so constructed that joints will not be opened by slight movement and swelling of the wood. Joints in the molds shall be broken and made inconspicuous by pointing with a mixture of equal parts of beef tallow and portland cement.

Intricate detail that cannot be formed with wood molds shall be cast in waste molds made from models approved by the Architect and shall be of such thickness and be so reinforced with fibre and a framework of wood that they may be readily handled without breakage. Waste molds shall be sized with two coats of thin shellac or lacquer. Wherever waste molds require pointing or patching, the work shall be done by a skilled mechanic furnished by the waste mold maker and the work shall be done with patching plaster and shall be shellacked or lacquered after drying but damaged molds shall not be patched without approval of the Architect.

The plaster waste molds shall be carefully set in the forms and securely held in the exact position to reproduce the design shown on the drawings. The framing of the wood form above the mold shall be sufficiently strong to remove all load from the molds. Where wood forms adjoin waste molds, the wood shall be neatly fitted to the profile of the molds and all joints shall be carefully pointed to eliminate jointing. The waste molds and adjacent wood forms shall be so detailed that the wood forms can be stripped without disturbing the waste molds.

(14) Form Ties—Form ties approved by the Architect shall be used. They shall have a minimum working strength when fully assembled of at least 3,000 lb. Ties shall be so adjustable in length as to permit tightening of forms and of such type as to leave no metal closer than 1½ in. of the surface and they shall not be fitted with any lugs, cones, washers or other device to act as a spreader within the form or for any other purpose which will leave a hole larger than 7/8 in. in diameter or a depression back of the exposed surface of the concrete. Wire ties will not be permitted.

Ties that are to be pulled from the wall shall be coated with cup grease or other approved material to facilitate removal.

Tie rods that are to be entirely removed from the wall shall be loosened 24 hours after the concrete is placed. All but a sufficient number of ties to hold the forms in place may be removed at that time, but the forms shall be held in position not less than 4 days, except that 2 days shall be considered sufficient if high early strength portland cement or concrete is used, but in no case shall ties or forms be removed until the concrete has hardened sufficiently to permit removal without damaging the concrete. Care shall be exercised to avoid spalling the concrete on the exposed surfaces. Ties of uniform diameter that are wholly withdrawn from the wall shall be pulled toward the inside face. Cutting ties back from face of wall will not be permitted. Tie rod holes shall be plugged as specified in Sec. 36.

(15) Wetting and Oiling Forms—The inside surface of wood board forms shall be soaked with clean water and kept continuously wet for 12 hours before any concrete is placed. In case forms have been erected for some time and have become dry so that joints have opened, then the forms shall be thoroughly soaked at least twice each day for at least 3 days prior to placing concrete. If the forms cannot be tightened to the satisfaction of the Architect they shall be torn down and rebuilt. Plywood and fibreboard forms shall be treated with an approved form oil or lacquer. If oil is used all excess oil shall be wiped off with rags to leave the surface of the forms just oily to the touch.

Plaster waste molds shall be greased with soft cup grease or cup grease thinned to a point where it can be applied with a brush by addition of a mixture of crystallized stearic acid and kerosene.

Coatings of dust shall be removed from contact surfaces of forms before placing concrete. Concrete shall not be placed in any form until inspected by the Architect and permission is given to start placing.

(16) Removing Forms—All wall forms shall be removed when the concrete has thoroughly hardened, but in no case in less than 4 days except when high early strength portland cement or concrete is used, in which case forms may be removed after 2 days. Waste molds shall be left in place until thoroughly dry and until all placing of concrete has been completed and in no case less than 14 days and shall then be carefully stripped off to prevent damage to the concrete.

REINFORCEMENT

(17) Cleaning—Metal reinforcement before being placed shall be thoroughly cleaned of mill and rust scale and of coatings that will destroy or reduce the bond. Reinforcement appreciably reduced in section shall be rejected. Where there is delay in depositing concrete, reinforcement shall be reinspected and when necessary cleaned.

(18) Bending and Straightening—Reinforcement shall be carefully formed to the dimensions indicated on the plans. Cold bends shall be made around a pin having a diameter of six or more times the least dimensions of the reinforcement bars.

Metal reinforcement shall not be bent or straightened in a manner that will injure the material. Bars with kinks or bends not shown on the plans shall not be used. Heating of reinforcement will be permitted only when the entire operation is approved by the Architect.

(19) Placing—Metal reinforcement shall be accurately positioned and secured against displacement by using annealed wire of not less than No. 16 gage or suitable clips at intersections and shall be supported in a manner that will keep all metal away from the exposed surface of the wall. Nails shall not be driven into the outside forms to support reinforcement nor shall any other device for this purpose come in contact with the outside form, except that wood strips shall be inserted between the reinforcement and the outside form at intervals to maintain the required clear distance between the reinforcement and the inside and outside surfaces of the concrete. The strips shall be pulled up and removed from the wall as the level of the concrete rises. The minimum clear distance between any bar and the weather side of all exterior walls shall not be less than 2 in. At all wall surfaces not exposed to the weather a minimum of 1 in. of concrete cover over all steel shall be provided.

(20) Splicing—Wherever it is necessary to splice reinforcement otherwise than as shown on the plans, the character of the splice shall be decided by the Architect on the basis of allowable bond stress and the stress in the reinforcement at the splice. Splicing shall not be made at points of maximum stress nor shall adjacent bars be spliced at the same point.

All bars shall be lapped at least 40 diameters at all corners and at abrupt changes in directions of walls.

PROPORTIONING

(21) General—Fine and coarse aggregates shall be proportioned by direct weight upon suitable weighing devices approved by the Architect. Portland cement in standard unopened cloth or paper sacks as packed by the manufacturer may be considered as weighing 94 lb. per sack.

(22) Measuring Ingredients—All measurements of fine and coarse aggregates shall be made separately by weight. Proportioning aggregates for fractional sacks of cement will not be permitted unless the cement is weighed for each batch. Weighing equipment shall be arranged to permit making compensation for changes in the weight of moisture contained in the aggregates. Weighing equipment shall meet the approval of the Architect and shall be accurate within 1 per cent of the net load being weighed.

A satisfactory auxiliary device shall be used in connection with the scale beam to indicate or register at least the last 100 lb. of each of the aggregates required for the batch.

Water shall be measured by an approved device capable of accurate measurement to 1 pt., plus or minus, of the total amount of water required per batch.

(23) Water-Cement Ratio—The proportioning of materials shall be based on the requirements for a plastic and workable mix with the use of not less than 5½ sacks of cement per cu. yd. and not more than 6½ gal. of water per sack of cement including the surface water carried by the aggregate, expressed in terms of the quantity of cement. The water in the aggregate must be included in the quantity specified and subtracted from the amount added to the mixture. It shall be measured by methods satisfactory to the Architect which will give results within 1 lb. for each 100 lb. of aggregate. Moisture determinations shall be made on representative samples at least once each day and at such times as the appearance of the aggregate or the mixed concrete indicates a change in moisture content.

(24) Proportioning and Consistency—The proportions of aggregate to cement shall produce concrete that can be thoroughly compacted. The slump shall not exceed 4 in. when vibration equipment is used and in no case shall the slump exceed 6 in.

The combined aggregate shall be of such composition of sizes that when separated by the No. 4 standard sieve the weight retained on the sieve shall be not less than one-half nor more than two-thirds of the total based on dry materials, except where adjustment is necessary in the opinion of the Architect for casting in special details.*

(25) Trial Batches—Full size trial batches shall be made in the mixer using the aggregates selected for the job to establish the correct proportions of the mix to give proper workability without exceeding the water-cement ratio and slump specified. If the desired workability is not obtained with the first combination of aggregates, then the proportions of fine and coarse aggregate shall be adjusted within the limits specified until the mix meets with the approval of the Architect.

(26) Mixing—Concrete shall be mixed in a batch mixer not larger than ½-cu. yd. capacity for not less than 1 minute after all the materials are in the mixer drum and until there is a uniform distribution of the materials and the mass is uniform in color and is homogeneous. The mixer shall rotate at a peripheral speed of about 200 ft. per minute and shall not be loaded above its rated capacity.

(27) Central or Transit-Mixed Concrete—Concrete from a central plant or mixed in transit-mixer trucks may be used if it complies with these specifications. The Architect shall have free access at all times to the batching and mixing plant for sampling of all materials and inspection of work performed for this project. Concrete shall be delivered in watertight containers which will not permit segregation of the materials. When delivered, the concrete shall be uniform throughout the mass.

DEPOSITING CONCRETE

(28) Cleaning Equipment—Before beginning a run of concrete, hardened concrete and foreign materials shall be removed from the inner surfaces of the mixing and conveying equipment. All conveyances, buggies, or barrows shall be thoroughly cleaned at frequent intervals during the placing of the concrete.

(29) Transporting—Concrete shall be handled from the mixer to place of final deposit in carts, buggies or conveyors. Concrete shall not be spouted nor delivered by spout or trough from the hoists, nor dumped into carts with a free fall from the mixer of more than 3 ft. Every possible precaution shall be taken to prevent separation or loss of the ingredients while transporting the concrete. Delivery carts or buggies shall be kept on temporary runways built over the floor system and runway supports shall not bear upon reinforcing steel or fresh concrete.

(30) Time of Placing—Before starting work on any exposed concrete the Contractor shall construct complete and finish a section of basement wall or other unexposed wall when directed by the Architect as a demonstration panel, using the same materials and methods of construction as will be used for exposed surfaces. The panel must be approved by the Architect or additional panels must be built until one satisfactory to the Architect has been produced before starting any exposed work.

Concrete shall not be placed until all reinforcement is securely and properly fastened in its correct position, nor until the forms have been inspected and approved by the Architect and form ties at construction joints have been retightened, nor until all bucks, sleeves, hangers, pipes, conduits, bolts, wires and any other fixtures required to be embedded therein have been placed and anchored by the Contractor, nor until the forms and reinforcement have been cleaned and the forms oiled or lacquered as specified in Sec. 15. Concrete shall not be placed at any time except under the direct supervision of the Architect nor outside of regular working hours unless the Architect is notified at least 4 hours in advance and Architect's superintendent or inspector is on the job.

(31) Placing—Special care must be exercised to prevent segregation of the concrete and to prevent splashing the forms or reinforcement with concrete and any such splashes or accumulations of hardened or partially hardened concrete on the forms or reinforcement above the general level of the concrete already in place must be removed before the work proceeds. Concrete shall be placed through canvas "elephant trunks" or galvanized iron chutes equipped with suitable hopper heads. Chutes or trunks shall be of variable lengths so that the free fall shall not exceed 3 ft., and a sufficient number shall be placed in the forms to insure the concrete being kept level at all times. Sufficient illumination shall be provided in the interior of the forms so that the concrete at places of deposit is visible from the deck and runways. Plaster waste molds shall be protected by a canvas cover over the inside face of each mold which shall remain in place until the level of the concrete in the wall form reaches the middle of the mold or a point at least 1 ft. above the bottom of the mold. The canvas shall be slowly lifted, allowing the concrete to enter the mold. Every precaution shall be taken to completely fill the mold.

Concrete shall not be placed at a rate faster than 2 ft. per hour and shall be spaded to thoroughly embed all reinforcement and fixtures. Spading shall be supplemented by rapping the forms with rubber hammers or wooden mallets or by light pneumatic or electric hammers (chipping guns) applied to the studs and wales at the level of the concrete being placed. When forms are removed, surfaces shall be even and dense, free from aggregate pockets or honeycomb.

(31a) Placing with Vibration—Concrete may be placed with the aid of mechanical vibrating equipment. Where vibration is used it shall be applied directly to the concrete unless otherwise approved by the Architect. The intensity of vibration shall be sufficient to cause flow or settlement of the concrete into place. Vibration shall be applied at the point of deposit and in the area of freshly placed concrete. It shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures but shall not be long enough to cause segregation of the mix. To secure even and dense surfaces, free from aggregate pockets or honeycomb, vibration shall be supplemented by hand spading in the corners and angles of forms and along form surfaces while the concrete is plastic under the vibratory action.

(32) Construction Joints and Stoppages—The placing of concrete shall be carried on continuously between construction joints shown on the drawings.† If for any reason it shall become necessary to stop the placing of concrete at places other than those indicated, such places shall have the approval of the Architect.

Immediately after concrete placement is completed, the rein-

* In practically all cases the regular mix can be used for casting details. Where detail is intricate it may be necessary to reduce the amount of coarse aggregate but it is rarely necessary to reduce the maximum size.

† In the exterior walls it is desirable to locate horizontal construction joints at well defined lines such as window sills or heads, rustications or water tables. Joints at the tops of windows allow considerable shrinkage to occur in the concrete panel between the windows, thereby minimizing the possibility of shrinkage cracks.

forcement projecting above the concrete shall be thoroughly cleaned. The surface of the concrete shall be level whenever a run of concrete is stopped. To insure a level, straight joint on the exposed surface of the walls one of the following methods shall be used. *Method 1*—A strip of 1-in. square-edged dressed board shall be set level and tacked to the forms at the outside surface of the wall. The concrete shall be carried about ½ in. above the underside of the strip. About 1 hour after the concrete is placed, the strip shall be removed and any irregularities in the joint line shall be leveled off with a screed. The following day all laitance shall be removed with a stiff wire brush, leaving the aggregate exposed. *Method 2*—The form sheathing shall be stopped exactly at the elevation of the construction joint and shall be brought to a true level line. The concrete shall be heaped up above the joint and the excess concrete shall be struck off to the level of the top of the sheathing. Surface of concrete between outside form and reinforcement shall be screeded and concrete back of reinforcement shall be wire brushed the following day to expose the aggregate.

Wherever horizontal construction joints are made, ⅝-in. bolts shall be provided 3 to 4 in. below the joint at the same spacing as regular ties with which to tighten the forms against the hardened concrete.

Vertical stops shall be placed at interior corners only, unless otherwise shown on the drawings or approved by the Architect.

(33) Depositing Against Other Concrete—Before depositing new concrete on or against concrete that has hardened, the forms shall be retightened, the surface of the hardened concrete shall be roughened as required, thoroughly cleaned of foreign matter and laitance, and moistened with water. The new concrete placed in contact with hardened or partially hardened concrete shall contain an excess of mortar to insure bond. To insure sufficient mortar at the juncture of the hardened and the newly deposited concrete, a layer of concrete containing only one-half the amount of coarse aggregate in the regular mix shall be deposited against the hardened concrete to a thickness of at least 2 in. This shall be followed by the regular mix concrete.

(34) Protecting and Curing—All exposed surfaces of concrete shall be protected from premature drying and freshly placed concrete shall be protected against wash by rain. All concrete shall be kept wet for a period of 5 days after placing, except that 2 days' curing shall be considered sufficient if high early strength portland cement or concrete is used. In order that curing water may reach both surfaces of walls, the forms shall be loosened and water shall be poured over the tops of the walls and allowed to run down between the concrete and the forms.

(35) Depositing in Cold Weather—Concrete when deposited shall have a temperature not below 50 deg. F. and not above 70 deg. F. In freezing weather suitable means shall be provided for maintaining the concrete at a temperature not lower than 70 deg. F. for 3 days, or 50 deg. F. for 5 days after placing, except when high early strength portland cement or concrete is used the temperature must be maintained at not less than 70 deg. F. for 2 days or 50 deg. F. for 3 days. Cooling of the concrete to outside temperature shall not be at a rate faster than 1 deg. each hour for the first day and 2 deg. each hour thereafter until the outside temperature is reached. The methods of heating the materials and protecting the concrete shall be approved by the Architect. Salt, chemicals, or other foreign materials shall not be mixed with the concrete for the purpose of preventing freezing.

(36) Patching—Any concrete which is not formed as shown on the plans, or for any reason is out of alignment or level or shows a defective surface, shall be considered as not conforming with the intent of these specifications and shall be removed from the job by the Contractor at his expense, unless the Architect grants permission to patch the defective area, which shall be done in accordance with the following procedure. Permission to patch any such area shall not be considered a waiver of the Architect's right to require complete removal of the defective work if the patching does not, in his opinion, satisfactorily restore the quality and appearance of the surface.

After removing forms, all concrete surfaces shall be inspected and any poor joints, voids, stone pockets or other defective areas permitted by the Architect to be patched and all tie holes shall be patched. Where necessary, defective areas shall be chipped away to a depth of not less than 1 in. with the edges perpendicular to the surface. The area to be patched and a space at least 6 in. wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar. A grout of equal parts portland cement and sand, with sufficient water to produce a brushing consistency, shall then be well brushed into the surface followed immediately by the patching mortar. The patch shall be made of the same material and of approximately the same proportions as used for the concrete except that the coarse aggregate shall be omitted. The mortar shall not be richer than 1 part cement to 3 parts sand. White portland cement shall be substituted for a part of the gray portland cement to match the color of the surrounding concrete. The proportion of white and grey cements shall be determined by making a trial patch. The amount of mixing water shall be as little as consistent with the requirements of handling and placing. The mortar shall be re-tempered without the addition of water by allowing it to stand for a period of 1 hour during which time it shall be mixed occasionally with a trowel to prevent setting.

The mortar shall be thoroughly compacted into place and screeded off so as to leave the patch slightly higher than the surrounding surface. It shall then be left undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface. On exposed surfaces where unlined forms have been used the final finish shall be obtained by striking off the surface with a straight-edge spanning the patch and held parallel to the direction of the form marks. All patches shall be cured in accordance with Sec. 34.

Tie holes left by withdrawal of rods or the holes left by removal of ends of ties shall be filled solid with mortar after first being thoroughly wetted. For holes passing entirely through the wall a plunger type grout gun shall be used to force the mortar through the wall starting at the back face. A piece of burlap or canvas shall be held over the hole on the outside and when the hole is completely filled the excess mortar shall be struck off with the cloth flush with the surface. Holes not passing entirely through the wall shall be filled with a small tool that will permit packing the hole solid with mortar. Any excess mortar at the surface of the wall shall be struck off flush with a cloth.

(37) Cleaning Walls—No cleaning operations shall be undertaken until the walls of the building are entirely completed including all patching and filling of tie holes. Cleaning portions of the walls as the work progresses will not be permitted.

If, in the opinion of the Architect, the surface of the concrete shows a film of oil left from an excess of oil on the forms, or the concrete is oil-stained, or is otherwise not of uniform color, he may require the following cleaning method to be used for which the Contractor shall make allowance in his proposal in accordance with the final paragraph of this section:

Mix 1 part portland cement and 1½ parts fine sand with sufficient water to produce a grout having the consistency of thick paint. White portland cement shall be used for all or part of the cement in the grout as directed by the Architect to give the color desired. Wet the surface of the concrete sufficiently to prevent absorption of water from the grout and apply the grout with brushes or a spray gun uniformly, completely filling air bubbles and holes. Immediately after applying the grout, float the surface with a cork or other suitable float, scouring the wall vigorously. While the grout is still plastic the surface shall be finished with a sponge rubber float removing all excess grout. This finishing shall be done at the time when grout will not be pulled from holes or depressions. Next allow the surface to dry thoroughly, then rub it vigorously with dry burlap to completely remove any dried grout. There shall be no visible film of grout remaining after this rubbing. The entire cleaning operation for any area must be completed the day it is started. No grout shall be left on the wall overnight.

After the entire building has been grout cleaned, if any slightly dark spots or streaks remain they shall be wiped off lightly with a fine abrasive hone without using water but the rubbing with the hone shall not be sufficient to change the texture of the concrete. This final operation shall be included as a part of the grout cleaning.

In submitting his proposal, the Contractor shall include for Cleaning $——. If the treatment is deemed unnecessary by the Architect, proper credit shall be allowed the Owner.

SPECIFICATIONS FOR CONCRETE FLOOR FINISH

(1) Base Slab—The surface of the structural base slab shall be finished reasonably true and struck off at a level not less than 1 in. below the required finish grade.

As soon as the condition of the concrete base permits and before it has fully hardened, all dirt, laitance and loose aggregate shall be removed from the surface by means of a wire broom which shall leave the coarse aggregate slightly exposed, or the surface otherwise roughened to improve bond with the topping.

When it is impossible to remove laitance and roughen the slab by brooming, the surface shall be cleaned and prepared for bond by chipping after the base has hardened.

Just prior to placing the finish, the base slab shall be thoroughly cleaned by scrubbing, to the satisfaction of the Engineer.

(2) Portland Cement—Portland cement shall conform to the "Standard Specifications for Portland Cement" (ASTM Designation: C150-55) and shall be Type——.

These specifications cover five types of portland cement as follows and provide that "when no type is specified, the requirements of Type I shall govern"*.

"**Type I**—For use in general concrete construction when the special properties specified for Types II, III, IV and V are not required.

"**Type II**—For use in general concrete construction exposed to moderate sulfate action, or where moderate heat of hydration is required.

"**Type III**—For use when high early strength is required.

"**Type IV**—For use when low heat of hydration is required. (See Note.)

"**Type V**—For use when high sulfate resistance is required. (See Note.)

"**NOTE**—Attention is called to the fact that cements conforming to the requirements for Type IV and Type V are not usually carried in stock. In advance of specifying their use, purchasers or their representatives should determine whether these types of cement are, or can be made available."

* These paragraphs, including Note, quoted from above specifications.

(3) Aggregates—Fine aggregate shall consist of clean, hard sand or crushed stone screenings free from dust, clay, loam or vegetable matter and shall be graded from coarse to fine to meet the following requirements:

Passing ⅜-in. sieve	100 per cent
Passing No. 4 sieve	95 to 100 per cent
Passing No. 16 sieve	45 to 65 per cent
Passing No. 50 sieve	5 to 15 per cent
Passing No. 100 sieve	0 to 5 per cent

Coarse aggregate shall consist of clean, hard gravel or crushed stone free from dust, clay, loam or vegetable matter, and from coatings which will tend to weaken the bond. It shall contain no soft, flat or elongated fragments and shall be graded to meet the following requirements:

Passing ½-in. sieve	100 per cent
Passing ⅜-in. sieve	95 to 100 per cent
Passing No. 4 sieve	40 to 60 per cent
Passing No. 8 sieve	0 to 5 per cent

All aggregates shall be selected with care and shall be of an approved character. Samples of proposed material shall be submitted to the Engineer for approval prior to use.

(4) Mixture—The mixture shall be 1 part of portland cement, 1 part of fine aggregate and 2 parts of coarse aggregate by volume. This nominal mix may be slightly varied, depending upon the local conditions, and as the Engineer may direct. If the aggregate is very coarse, the gravel or stone may be reduced, but in no case shall the volume of the coarse material be less than 1½ times the volume of the fine.

The mixture shall be determined by the Engineer and once established shall not be changed except upon his written order.

Not more than 4 gal. of mixing water, including the moisture in the aggregates, shall be used for each sack of portland cement in the mixture when floating is done by machine and not more than 5 gal. when floating is done by hand. Mixing of the concrete shall continue for at least 1½ minutes after all ingredients are in the mixer.

(5) Consistency—The concrete shall be of the driest consistency possible to work with a sawing motion of the strike-off board. Changes in consistency shall be obtained by adjusting proportions of fine and coarse aggregate within limits specified. In no case shall specified amount of mixing water be exceeded.

(6) Placing and Compacting—The base slab shall be thoroughly wetted just prior to placing of finish, but there shall be no pools of water left standing on the wetted surface. A thin coat of neat cement grout shall be broomed into the surface of the slab for a short distance ahead of the topping. Wearing course shall be applied before the grout has hardened, and brought to the established grade with a straightedge. After striking off the wearing course to the established grade, it shall be compacted by rolling or tamping, and then floated with a wood float or power floating machine. The surface shall be tested with a straightedge to detect high and low spots, which shall be eliminated.

Millions of feet and thousands of loaded trucks have passed over the corridor floors of the station platforms at Grand Central Terminal in New York City since it was built nearly forty years ago. They are still in excellent condition and have required practically no maintenance in all those years.

(7) Finishing by Troweling—Floating shall be followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface. The finish shall be brought to a smooth surface free from defects and blemishes. No dry cement nor mixture of dry cement and sand shall be sprinkled directly on the surface of the wearing course to absorb moisture or to stiffen the mix. After the concrete has further hardened, additional troweling may be required. This shall be done as may be directed by the Engineer.

NOTE: Surfaces to be ground shall be swept with soft brooms after rolling to remove any water and surplus cement paste that may be brought to the surface. The wearing course shall then be floated and once lightly troweled, but no attempt shall be made to remove all trowel marks.

(8) Curing and Protection—All freshly placed concrete shall be protected from the elements and from all defacement due to building operations. The Contractor shall provide and use tarpaulins when necessary to cover completely or enclose all freshly finished concrete.

If at any time during the progress of work the temperature is, or in the opinion of the Engineer will, within 24 hours, drop to 40 deg. F., the water and aggregate shall be heated so that the temperature of the mixed concrete at the time of placing is between 50 and 70 deg. F. Precautions shall be taken to maintain the temperature of the concrete above 70 deg. F. for at least 3 days or above 50 deg. F. for at least 5 days when using normal portland cement and above 70 deg. F. for at least 2 days or above 50 deg. F. for at least 3 days when using high early strength portland cement.

As soon as the concrete has hardened sufficiently to prevent damage thereby, it shall be covered with at least 1 in. of wet sand, or other covering satisfactory to the Engineer, and shall be kept continually wet by sprinkling with water for at least 7 days when using normal portland cement or for at least 3 days when using high early strength portland cement. In lieu of other curing methods, the concrete may be covered with a colorless curing compound or with asphalt-impregnated, waterproof paper. All seams of such paper shall be overlapped and sealed with tape.

NOTE: When surface is to be finished by grinding add following section.

(9) Finishing by Grinding—After the wearing course has hardened sufficiently to prevent dislodgment of aggregate particles, it shall be ground down with an approved type of grinding machine shod with rapid-cutting abrasive stones to expose the coarse aggregate. The floor shall be kept wet during the grinding process. All material ground off shall be removed by squeegeeing and flushing with water.

Air holes, pits and other blemishes shall then be filled with a cement grout of creamy consistency. This grout shall be spread over the surface and worked into the pits with a steel straightedge, after which the grout shall be rubbed into the floor surface with the grinding machine. The floor shall be kept wet an additional 3 days, but for not less time than required under Sec. 8.

The floor surface shall then receive a second or final grinding to remove the film and to give the finish a polish. It shall then be thoroughly washed and all surplus material removed.

PARTIAL LIST OF PUBLICATIONS RELATING TO CONCRETE MASONRY AND CONCRETE FLOORS

CONCRETE MASONRY FOR SCHOOLS—Illustrates the adaptability of exposed, painted concrete masonry for interiors and exteriors of schools.

MORTARS FOR MASONRY WALLS—Discusses desirable properties of mortar. Includes tables of recommended mortar mixes for different types of service, and of quantities of materials required for various mortar mixes.

CONCRETE MASONRY CONSTRUCTION IN COLD WEATHER—Recommended practices for concrete masonry construction in cold weather. Photographs illustrate important precautions to be observed.

SUGGESTED PATTERNS WITH CONCRETE MASONRY—Drawings illustrate a wide variety of attractive patterns in which concrete masonry can be laid.

CONCRETE MASONRY HANDBOOK FOR ARCHITECTS, ENGINEERS AND BUILDERS — A comprehensive handbook for designers and builders, illustrated with photos, tables and drawings, demonstrating the various steps involved in the construction of concrete masonry buildings.

HOW TO CALCULATE HEAT TRANSMISSION COEFFICIENTS AND VAPOR CONDENSATION TEMPERATURES OF CONCRETE MASONRY WALLS — Principles and methods of calculating heat loss and vapor condensation temperatures are set forth in accordance with the best present-day work in this field. Tables of thermal properties of materials and of the various combinations of these materials are in ready reference form.

BEAUTIFUL WALLS WITH CONCRETE MASONRY — Illustrates many fine examples of exposed concrete masonry walls and demonstrates the adaptability of this material to practically any type of structure. Color photos show various patterns, textures, tooling and workmanship.

RECOMMENDED PRACTICES FOR LAYING CONCRETE BLOCK — A practical fully-illustrated guide describing recommended practices for quality concrete masonry construction.

SUGGESTED SPECIFICATIONS FOR CONCRETE MASONRY HOUSE CONSTRUCTION — Individual specification sheets covering various types of floors; walls and footings; application of concrete floor finishes and coverings; stairs and steps, walks, terraces; portland cement paint and portland cement stucco on concrete masonry, mortar mixes and other details.

SUGGESTED DETAILS OF CONCRETE MASONRY CONSTRUCTION — Comprehensive set of detailed drawings on concrete masonry construction. Particularly useful in drafting rooms as all drawings have been reproduced to an exact 1-in. scale so they can be readily traced.

SPECIFICATIONS FOR CONCRETE MASONRY UNITS — Published by The American Society for Testing Materials covering hollow load-bearing, hollow non-load-bearing and solid load-bearing concrete masonry units; also concrete building brick.

PRECAST CONCRETE JOISTS IN FLOOR AND ROOF CONSTRUCTION — A manual on the design and construction of concrete floors and roofs using precast concrete joists, illustrated with detailed drawings and construction photos. Includes design tables for selecting precast concrete joists for light-occupancy structures, such as residences, office buildings, schools, etc.

HOW TO DESIGN AND BUILD LOW-COST CONCRETE BLOCK JOIST FLOORS — Discusses the design and construction of concrete block joist floors for residential and other light-occupancy buildings. Design tables and construction details are also included.

Inquiries are invited on any question involving the uses of cement or concrete. The assistance of our technical staff is available to designers and builders of all types of construction projects. Address the Portland Cement Association, 33 W. Grand Ave., Chicago 10, Ill., or nearest district office listed below.

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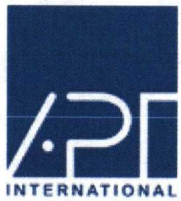

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